REMARKS

Claims 1-6, 11, 13, 14, 17-18, 20, 22-24, 26, 28-30, 32, 34-38, 40, 41 and 47 were in this case. Claims 38 and 40 were withdrawn as directed to a non-elected invention. This amendment cancels claims 38 and 40 and adds new claims 48 to 54. Claims 1-6, 11, 13, 14, 17-18, 20, 22-24, 26, 28-30, 32, 34-37, 41 and 47-54 are now in this case.

Amendment of the Claims

Claims 11 and 13 are amended to improve antecedent basis by now reciting "one or more nonlinear optical or saturable absorber elements or devices."

Claim 22 has been amended to make it an independent claim incorporating the elements of claims 1 from which it originally depended. It is believed that claim 22 is now allowable.

Claim 34 has been amended to make it an independent claim incorporating the elements of claims 1 from which it originally depended. It is believed that claim 34 is now allowable.

Claim 37 is amended to specify that it is a mode-locked pulsed laser wherein the mode-locking device or element functions in mode-locking of the laser.

Claim 41 has been amended to make it depend from claim 26 and to improve antecedent basis. This method claim has also been amended to recite a step of operating the laser in the mode-locked regime.

Claim 47 has been amended to better claim that which Applicant considers to be the invention by reciting that the method can be practiced by Q-switching <u>or mode-locking</u> the laser of claim 1. This amendment to add the alternative step of mode-locking is supported by the specification at page 18, lines 13-15 which indicates that a laser of Figure 1 can be operated in the Q-switching regime or the mode-locking regime.

New claims 48-52 have been added. Claims 48 and 49 recite that the nonlinear optical or saturable absorber elements or devices of the laser of claim 1 are waveguides or optical fibers, respectively. These claims are supported in the specification in Figures 18A-18L.

New clams 50 and 51 recite that the carbon nanotubes of the elements of claim 26 are in a waveguide or an optical fiber, respectively. These claims are also supported in Figures 18A-18L.

New claim 52 is directed to a laser that contains the mode-locking element of claim 34. It is believed that new claim 52 is allowable. This claim is supported by as filed claim 37.

New claims 53 and 54 are directed to mode-locked pulsed lasers of claim 1 and 37, respectively, which operate in the picosecond or sub-picosecond regimes. This amendment is supported in the specification in the paragraph bridging pages 2 and 3 in the discussion of mode-lockers possessing a fast and a slow recovery time for effective pulsed operation in the picosecond and sub-picosecond regimes.

The claim amendments are fully supported by the specification as filed and do not add new matter to the applications

Claim Objections

Claim 1 was objected to for informalities. Claim 1 has been amended as suggested by the Examiner which is believed to obviate this rejection.

The Rejections

Claims 26, 28-30, 32, 35-37 and 41 are rejected under 35 U.S.C. 102(e) as being anticipated by Sakaibara et al. Applicants respectfully traverse this rejection.

The Office Action states:

Fig. 5 shows a laser mode locking element comprising one or more layers containing carbon nanotubes (SWNT's) 11 (it is understood that carbon nanotubes are used for the saturable absorption function (saturable absorber) and therefore the laser is mode-locked as admitted in the disclosure of this instant application on page 2).

With respect to claims 29-30, para. 0022 discloses the carbon nanotubes are selected to have a range of different diameters to provide a wide operating bandwidth.

With respect to claim 32, para. 0070 and 0075 disclose the carbon nanotubes are capable of operating in both reflection and transmission mode.

With respect to claim 35, Fig. 5 shows a layer of carbon nanotubes 11 is provided on a substrate surface 12.

With respect to claim 36, Fig. 6 shows the other face of the substrate 12 is provided with a half mirror 14.

Claim 26 (as well as claims 28-30, 32, and 35-36) are directed to laser mode-locking elements or devices. Claim 37 is directed to a mode-locked pulsed laser comprising the mode-locking element or device of claim 26 which function in mode-locking of the mode-locked pulsed laser. Claim 41 is directed to a method generating light pulses by providing a laser-mode locking element or device of claim 26 and operating the laser in the mode-locked regime.

With respect to the characterization of Sakaibara et al. Fig. 5, this figure illustrates “a variable transmittance type optical switch.” There is no disclosure or discussion in the reference that the device illustrated in Fig. 5 is or can be used as a laser mode-locking element or device. The reference at para. 0093 indicates that an existing pulsed laser was employed to assess the optical switching properties of the optical switch of Fig, 5, but there is no teaching or suggestion that the optical switch itself could be used for mode-locking of a laser as is required in the claims. The optical switching device of Fig. 5 was not used to mode-lock the laser used in the experiment described.

Applicants have not admitted that the device of Fig.5 of the Sakaibara et al reference functioned as a mode-locking device for a laser. Applicants have reviewed page 2 of the instant application and see no such admission. Applicants respectfully request clarification of the alleged “admission” that is made on page 2 of the specification.

As defined in the specification in the paragraph bridging pages 2 and 3, a “mode locker “is a type-of saturable absorber that exhibits additional properties beneficial for functioning to mode lock a laser. A mode locker material, which is the functional material in a mode-locker element or device useful in laser configurations herein, should preferably possess both a fast and a slow recovery time in order to be used effectively in a pulsed laser operating in the picosecond and sub-picosecond regimes. There are many materials possessing nonlinear properties (such as saturable absorption) that do not possess the properties of a mode-locker. The CNT materials including layers containing SWNTs, or a combination of SWNTs and MWNTs exhibit mode-locker properties.” Applicants have determined that nonlinear optical and saturable absorber elements containing carbon nanotubes exhibit both a fast and slow recovery time that allows these materials to be effectively used for pulsed lasers, particularly for pulsed lasers which operate in the picosecond and sub-picosecond regimes. The existence of the slow recovery property of the carbon nanotube materials and particularly the existence of slow and fast recovery in the same materials was not known in the prior art.

The Sakaibara et al. reference does not teach a laser mode-locking element or device containing carbon nanotubes. The reference does not teach a laser in which such an element is employed for mode-locking to generate laser pulses and the reference does not teach a method of generating light pulses in which such a mode-locking element or device is used to generate light pulses in a laser system. The Sakaibara et al. reference does not anticipate any of the pending claims.

As noted above, Sakaibara et al. does not teach the use of a saturable absorber element or device containing carbon nanotubes for mode-locking a laser to generate

laser pulses. Sakaibara et al. does not teach the use of such a device to make a mode-locked pulsed laser which operates in the picosecond and sub-picosecond regimes (as is claimed in new claims 53 and 54. All of the pending claims should be considered patentable over the cited reference. This rejection should be withdrawn.

Claims 1-6, 11, 13-14, 18, 20, 23-24, and 47 are rejected under 35 U.S.C 103(a) as being unpatentable over US 6,539,041 (Scheps) in view of Sakaibara et al. Applicants respectfully traverse this rejection.

Scheps is characterized as showing a laser for generating light pulses at a selected operating wavelength or range of wavelengths and a selected fundamental repetition frequency. Scheps is characterized as showing a laser which comprises one or more nonlinear optical or saturable absorber elements (110). Element 110 of Scheps is labeled “Passive Q-Switch.” In column 2, lines 18-21, Scheps states that the Q-Switch may be made from $Cr^{4+:}$YAG or a solid state host such as PMMA (Plexiglass) or ORMISIL(Sol-gel) doped with a saturable laser dye…” As stated by the Examiner, Scheps lacks one or more saturable absorbers comprising carbon nanotubes.

Sakaibara et al. is characterized as teaching one or more saturable absorbers comprising carbon nanotubes. It is then alleged that it would have been obvious to one of ordinary skill in the art to provide Scheps what is taught by Sakaibara et al., presumably to employ the saturable absorber of Sakaibara et al. which has high saturable absorption function with extremely low cost and efficiency.

Applicants disagree. Sakaibara et al. does not teach or suggest that the saturable absorber containing carbon nanotubes will function as a mode-locking element or passive Q-switching element in a laser.

Saturable absorber materials and nonlinear optical materials that are useful for functioning in a mode locker and mode-locked laser must have properties in addition to nonlinear optical and saturable absorber effects and fast recovery time for efficiency use

in a laser. For example, as described in the specification on page 15, lines 11-20, suitable properties consist of both a fast and a slow recovery time for mode-locking and self-starting, respectively, of a laser (with the fast component dominating over slow component so that mode-locking will dominate over Q-switching mode), a suitable level of saturation fluence depending on the laser peak pulsed power to facilitate stable mode-locking (a laser will not mode-lock if the saturation fluence is too high, and will become unstable if the saturation fluence is too low.), a suitable nonlinear absorption level (high saturable absorption level could give rise to Q-switch instabilities, whilst mode-locking will not occur if the saturable absorption level is too small) an absorption level in the range of about 0.2dB to about 1.2dB is found to be a good mode-locking operating range.." These requirements of saturable absorbers for laser applications, particularly with respect to self-starting, are well-known in the art as illustrated, for example, in the on-line Encyclopedia of Laser Physics and Technology article on passive mode-locking provided by RP Photonics (http://www.rp-photonics.com/passive_mode_locking.html#top). A printout of this article is provided for the Examiner's information.

The disclosure of Sakaibara et al. shows only that the carbon nanotube materials studied are useful in optical switches. The disclosure does not demonstrate or imply that the carbon nanotube-containing materials will provide for self-starting or that the saturation fluence and saturable absorber levels are appropriate for mode-locking a laser.

Saturable absorber materials that are useful for passive Q-switching of a laser are typically those that have slower recovery times compared to materials useful for mode-locking (e.g., nanoseconds vs. picoseconds), see page 2 of the specification at lines 28-31. The disclosure of Sakaibara et al. that certain carbon nanotube materials exhibit saturable absorber properties does not imply that these materials would be useful for Q-switching. Additionally, other properties of the saturable absorber are important for it use in Q-switching including the losses in the high-loss state and the damage threshold intensity. Sakaibara et al. provides no disclosure concerning such

properties and as such does not imply that carbon nanotube-containing materials can be used for passive Q-switching of a laser.

Applicants have also demonstrated that nonlinear optical and saturable absorber materials containing carbon nanotubes can be used to create mode-locked, passively Q-switched and hybridly mode-operated pulsed lasers. Sakaibara et al. does not demonstrate or imply properties of these materials that are required for mode locking and Q-switching of lasers. Nor does this disclosure demonstrate or imply the use of these materials in a hybridly mode-operated laser.

With respect to mode lockers and mode locking lasers as claimed, the use of carbon nanotube-containing nonlinear optical or saturable absorber materials provide for mode locking that is self starting. In this regard, the carbon-nanotube containing materials were previously unknown to be useful for mode-locking.

With respect to passive Q-switched lasers as claimed, the use of carbon nanotube-containing nonlinear optical or saturable absorber materials provides new materials having properties useful for Q-switching. In this regard, the carbon-nanotube containing materials were previously unknown to be useful for Q-switching

With respect to hybridly mode-operated lasers as claimed, the use of carbon nanotube-containing nonlinear optical or saturable absorber materials provides a hybridly mode-operated laser which does not require liquid Helium cooling.

In view of the above arguments, all of the claims should be considered patentable over the references cited. This rejection should be withdrawn

Allowable Subject Matter

Applicants acknowledge that the Examiner considers the subject matter of claims 17, 22 and 34 to be allowable. Claims 22 and 34 have been rewritten in independent form including all the limitations of the base claim from which they depend. Claims 22

and 34 should now be allowable. New claim 52 is directed to a pulsed laser that contains the element or device of claim 34 and as such should also be considered to be allowable.

Conclusion

Applicants respectfully request reconsideration of all of the claims and withdrawal of all rejections. A Petition for Extension of Time for Three Months accompanies this submission. A fee of $510 for a small entity is believed to be due. This amendment cancels two claims one of which was independent, makes one independent claim dependent and adds 7 dependent claims. It is believed that excess claims fees for addition of five dependent claims are required ($125.00). Fee payments of $635.00 will be submitted on electronic filing of this submission. If the fees are not paid or are incorrect, the U.S. Patent Office is authorized to deduct any fee deficiency or credit any overpayment to deposit account 07-1969.

Respectfully submitted,

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